Air Quality Influences

California's air resource is a diverse system with many factors affecting quality and sustainable conditions. As shown in Figure 1, air resources are comprised from a regulatory perspective of many air basins with significant interaction between air basins. Wide variations in air quality are found throughout these air basins. Most air basins in northeast and northwest California have few to zero days in which State air quality standards are exceeded (non-attainment days), while the San Joaquin Valley, South Coast, Salton Sea, and San Diego air basins continue to have a high number of non-attainment days.

Santa Monica Freeway, Los Angles County. Snow peaked mountains are barely visible in the background.

Figure 1: California's air basins

Source: California Air Resources Board (ARB), 1999

Air resource characteristics are reflective of each air basin's specific airflow traits, physiographic features, and pollution emission sources. These are the characteristics that affect the air quality and health

of the ecosystems within each air basin. Additional factors that affect air quality in forests and rangelands are geographic location and seasonal variations. Better air quality is typically found in the northern, higher elevation, and more remote portions of the State typically associated with forest and rangeland areas, spatially removed from urban centers of pollution production/emissions.

Another fundamental characteristic of air quality in forest and rangeland areas is related to seasonal weather patterns. In the winter season, valley pollution sources (most notably the Sacramento Valley and San Joaquin Valley air basins) are often unable to transfer via interbasin wind flows because of an inversion layer capping pollution sources. This limits westerly pollution flows into some forest and rangeland air basins (ARB, 1996). See Second triennial review of the assessment of the impacts of transported pollutants on ozone concentrations in California.

Air pollution mechanisms in the Mountain Counties air basin and greater Sierra Nevada mountains: A substantial amount of work on air quality in forest and rangeland areas of the Sierra Nevada mountains has been assembled as part of the Sierra Nevada Ecosystem Project (SNEP) and in the Lake Tahoe Watershed Assessment (Cahill, 1996; Cliff and Cahill, 2000). These reports find that interbasin transport of anthropogenic (human caused) waste from the Sacramento and San Joaquin Valleys is the most significant mechanism for air pollution transport in the Sierra Nevada mountains. In the southern San Joaquin Valley and the central Sacramento Valley, pollution from urban vehicle emission, agricultural burning, industrial production, and agricultural pesticides application are the major sources of pollution impacting the Sierra Nevada mountains. This pattern develops when the western slopes of the mountains are heated, causing the air to rise in a chimney effect and move upslope to the crest and over into the basin. The strength of this flow pattern depends on the amount of heating. Therefore, the pattern is strongest in summer from April through late October.

In the Lake Tahoe area, this upslope transport pattern is strengthened and becomes even more frequent by the alignment to the mountain range across the prevailing westerly winds common at this latitude. These winds combine with the local terrain winds to force air up and over the Sierra Nevada mountains from upwind sources in the Sacramento Valley into the Lake Tahoe area (Cahill et al, 1996).

Other important pollution sources affect the Sierra Nevada mountains. These are the results of dust from unpaved and paved roads, wildland and prescribed fire, rural community fuel wood burning, and vehicle emissions in urbanized areas such as Lake Tahoe. Wildfire has been observed to have very negative affects on air quality at levels in violation of air quality standards. Less is known about the impacts of particulate matter pollution from prescribed burns.

It is important to note that localized wood burning is as detrimental as wildfires in generating particulate matter greater than 10 microns in size (PM10) and tends to last substantially longer in total exposure time. This type of localized wood burning is particularly harmful in areas that trap and contain smoke in the winter such as Truckee or Yosemite Valley.

Ozone (O^3) transport in the summer months is also of particular concern. These nitrogenous pollutants are effectively transferred from valley sources by westerly winds into mountainous regions where ozone can form. Ozone levels have not decreased over time as other emissions have and are predicted to have affects on vegetation (conifer) over the next decade.

Ozone transport in summer months is of particular concern in the Sierra Nevada mountains.

Nitrogen saturation of soils adjacent to major metropolitan areas is increasing. This pollutant is transferred from valley sources and deposited into the soil via rain and fog. Little is known of the long-term effects of this pollutant to forest health. However, the dry deposition of excess nitrogen (particles and gases) in ground water is a concern.

Findings on California air quality standards

An ambient air quality standard is the definition of "clean air." This standard establishes the concentration at which the pollutant is known to cause adverse health effects to sensitive groups within the population, such as children and the elderly. For some pollutants, California and national standards are very similar and are expressed in parts per million (PPM) of pollutants or as micrograms per cubic meter of air ($\mu g/m^3$) (Alexis et al., 2001). See California Air Resources Almanac.

Several key pollutant species define air quality standards. The pollutants and standards that are important to California's forest and rangeland resources are O^3 and suspended particulate matter (PM10 and PM2.5). Other important pollution measures that are relevant to forest and rangeland areas are visibility standards and acidification of bodies of water. The California Air Quality Standards' trends and compliance measures are discussed below.

Ozone

Ozone (O_3) is a colorless gas with a pungent odor. It is the chief component of urban smog. Ozone is not directly emitted as a pollutant but is formed in the atmosphere when hydrocarbon and oxides of nitrogen (NO/NO_2) pre-cursor emissions react in the presence of sunlight. Meteorology and terrain play major roles in O_3 formation. Generally, low wind speeds or stagnant air coupled with warm temperatures and cloudless skies provide for the optimum conditions. As a result, summer is generally the peak O_3 season.

Ozone levels are measured at monitoring sites within each air basin. The State standard for acceptable levels of O_3 is 0.09 PPM for one hour. When this level is exceeded in any monitored site, the entire day is tallied as a "non-attainment day."

Statewide O_3 levels and non-attainment days have been decreasing. However, O_3 levels remain high among the air basins traditionally known to have higher levels, such as the South Coast, San Joaquin Valley, and Mojave Desert air basins (Table 1).

Although days of non-attainment are very low or non-existent within the Great Basin Valley, Lake County, Lake Tahoe, North Coast, and the Northeast Plateau air basins, ozone still remains a chronic stress even in levels below the state standard (Table 1). See California Air Resources Board ADAM database.

Table 1. Number of days state ozone standard exceeded* by air basin, 1988-2002

	Year														
Air basin	**1988**	**1989**	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**
Great Basin Valleys	3	0	2	0	5	0	4	2	1	0	0	0	0	4	8
Lake County	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lake Tahoe	0	2	0	0	1	0	0	0	0	1	0	1	0	1	1
Mojave Desert	152	158	136	135	150	135	137	119	108	101	77	83	86	72	75
Mountain Counties	51	39	22	23	54	35	57	49	65	29	52	66	51	50	62
North Central Coast	14	10	11	12	9	12	6	8	16	1	10	3	3	3	8
North Coast	0	0	0	0	0	0	1	1	0	2	7	4	0	0	0
Northeast Plateau	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sacramento Valley	98	68	50	68	74	34	60	50	58	25	62	59	42	46	47
Salton Sea	107	119	83	86	100	113	126	124	98	91	73	66	54	81	68
San Diego	160	159	139	106	97	90	79	96	51	43	54	27	24	29	15
San Francisco Bay Area	41	22	14	23	23	19	13	28	34	8	29	20	12	15	16
San Joaquin Valley	156	148	131	133	127	125	118	124	120	110	90	122	114	123	127
South Central Coast	138	117	105	112	75	63	90	95	82	59	54	33	38	34	24
South Coast	216	211	185	184	190	185	165	153	141	144	107	111	115	121	116

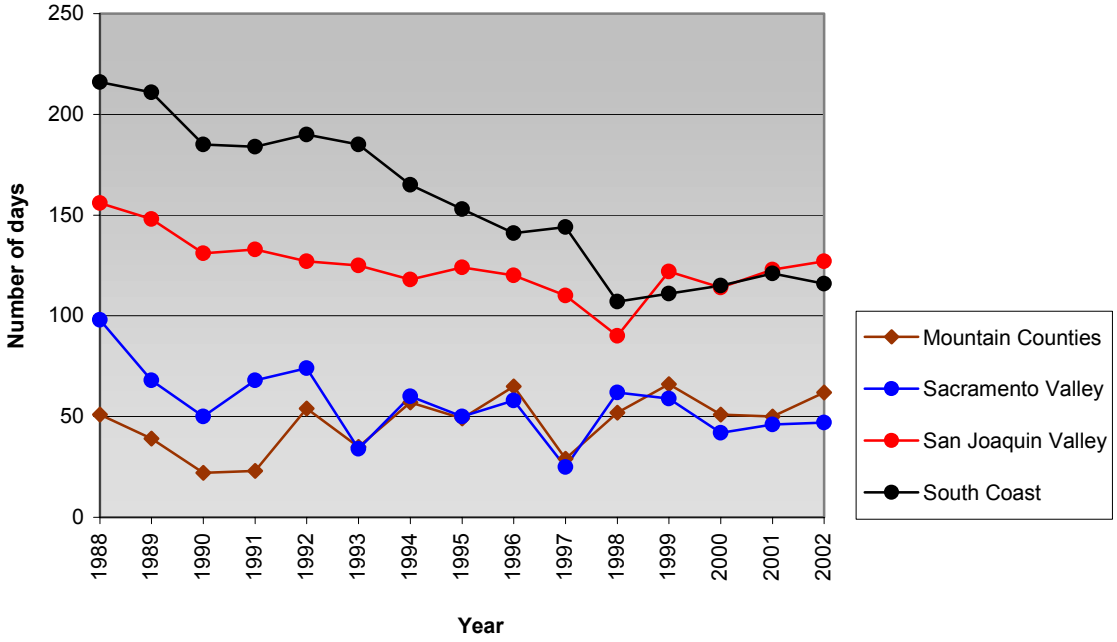
**State O^3 standard: 0.09 PPM for one hour, not to be exceeded.*

Source: California Air Resources Board (ARB), 1999

Los Angeles smog inversion, 1993, © Copyright: Bernhard Mühr

Ozone levels remain a particular concern to forest and rangeland resources in the Sierra Nevada mountains within the South Coast, San Joaquin, Sacramento Valley, and Mountain County air basins due to both high levels and affects (growth disruption and mortality) on trees and other vegetation. While O_3 levels within the South Coast air basin have dropped significantly over the past ten years, there was still a substantial amount of non-attainment in 2002 (116 days). The warm sunny weather associated with a persistent high-pressure system is conducive to O_3 formation. The surrounding mountains, and low air mass stability (inversion layer heights), produce stagnant air conditions helping to trap pollutants in the air basin. Similarly, in the San Joaquin Valley air basin, O_3 levels within have fallen over the past ten years (Figure 2); yet, they had 127 days of non-attainment. The San Joaquin Valley air basin differs from the South Coast in that there are a number of moderately sized urban areas spread along the main axis of the Valley instead of one large urban area (California Air Resources Board, 1999).

Figure 2. Number of days state ozone standard exceeded for selected air basins, 1988-2002



Source: California Air Resources Board (ARB), 1999

The primary source of the O_3 levels that drift east into the Sierra Nevada mountains has been linked to the intense biological/agricultural activity in the Sacramento and San Joaquin valleys. In these valleys, agricultural industries introduce biological sources of hydrocarbons and precursor O_3 gases such as nitrc oxide (Cahill et al., 1996). Vehicle emissions have been less of a concern as O_3 precursor gas emission standards have effectively reduced O_3 levels.

Ozone levels remain a particular concern to forest and rangeland resources within Sierra Nevada mountains and east of the San Joaquin and South Coast air basins.

The Sacramento Valley air basin continues to have sub-par O^3 levels, although to a lesser degree than the South Coast and San Joaquin air basins, with 47 days of non-attainment. As with the South Coast, O_3 precursors (oxides of nitrogen, hydrocarbons) are created from one single metropolitan area (Sacramento). In this case, on-road motor vehicles are the primary source of emissions. The Mountain Counties Air Basin, with 66 days of non-attainment, has seen O_3 levels slowly increase over the last ten years (California Air Resources Board, 1999).

Particulate matter (PM10 and PM2.5)

PM10 refers to particles with an aerodynamic diameter ten microns or smaller. (For comparison, the diameter of a human hair is approximately 50 to 100 microns). PM10 is a major air pollutant that consists of tiny solid or liquid soot, dust, smoke, fumes, or mist particles. The particles include elements such as carbon, lead, and nickel; compounds such as nitrates, organic compounds, and sulfates; and complex mixtures such as diesel exhaust and soil.

The size of the particles allows them to enter the air sacs deep in the lungs where they may be deposited, resulting in adverse health effects. PM10 also causes visibility reduction. The PM10 data are reported as 24-hour average concentrations in $\mu g/m^3$.

PM10 includes a subgroup of finer particles, PM2.5 (particulate matter 2.5 microns or smaller). PM2.5 particles pose an increased health risk because they can deposit deep in the lungs and contain substances that are particularly harmful to human health. The U.S. Environmental Protection Agency (EPA) created national PM2.5 standards in 1997, but trend information is limited at this time and final law application is pending.

Particulate matter can be directly emitted or can be formed in the atmosphere when gaseous pollutants such as sulfur and nitrogen oxides undergo chemical reactions in the atmosphere. Major sources of PM 10 include:

- motor vehicles;
- wood burning stoves and fireplaces;
- dust from construction, land fills, and agriculture;
- wildfires and brush or waste burning;
- industrial sources; and
- windblown dust from open lands.

The State PM10 Standards are 50 µg/m^3 for 24 hours average and 30 µg/m^3 annual average. The national PM2.5 standards are 65 µg/m^3 for 24 hours average and 15µg/m^3 annual average.

As shown below in Table 2 and Figure 3, PM10 with levels exceeding the State standards have been declining throughout most air basins within California. However, many areas continue to have high levels of particulate matter. Additionally, the Salton Sea and South Coast air basins continue to have very high levels of PM10 (Table 2). See California Air Resources Board ADAM database.

Table 2. Number of days PM 10 exceeded state standard by air basin, 1988 to 2002

	Year														
Air basin	**1988**	**1989**	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**
Great Basin Valleys	195	170	116	101	132	128	105	117	120	90	117	19	90	92	101
Lake County	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lake Tahoe	57	26	55	36	36	30	42	18	24	12	12	0	0	18	3
Mojave Desert	204	230	241	186	153	131	132	60	87	36	43	72	63	48	84
Mountain Counties	159	116	155	132	102	113	93	42	42	128	63	60	57	60	36
North Central Coast	24	18	18	12	0	59	30	72	72	96	30	54	24	51	30
North Coast	126	71	40	38	15	15	48	18	23	20	0	54	9	42	24
Northeast Plateau	21	26	25	12	24	6	24	54	18	18	24	66	60	36	36
Sacramento Valley	183	134	175	189	177	92	108	108	129	65	97	144	81	96	126
Salton Sea	252	294	286	294	186	239	274	306	312	320	265	324	330	341	328
San Diego	105	146	60	90	42	144	131	117	96	125	108	140	144	146	186
San Francisco Bay Area	123	137	93	125	108	59	54	42	18	20	25	63	42	51	30
San Joaquin Valley	300	302	313	285	273	233	253	246	225	188	185	216	237	236	267
South Central Coast	198	212	151	204	138	174	81	108	138	144	88	108	135	72	156
South Coast	345	338	301	294	282	293	276	252	276	290	238	288	300	278	297

Source: California Air Resources Board (ARB), 1999

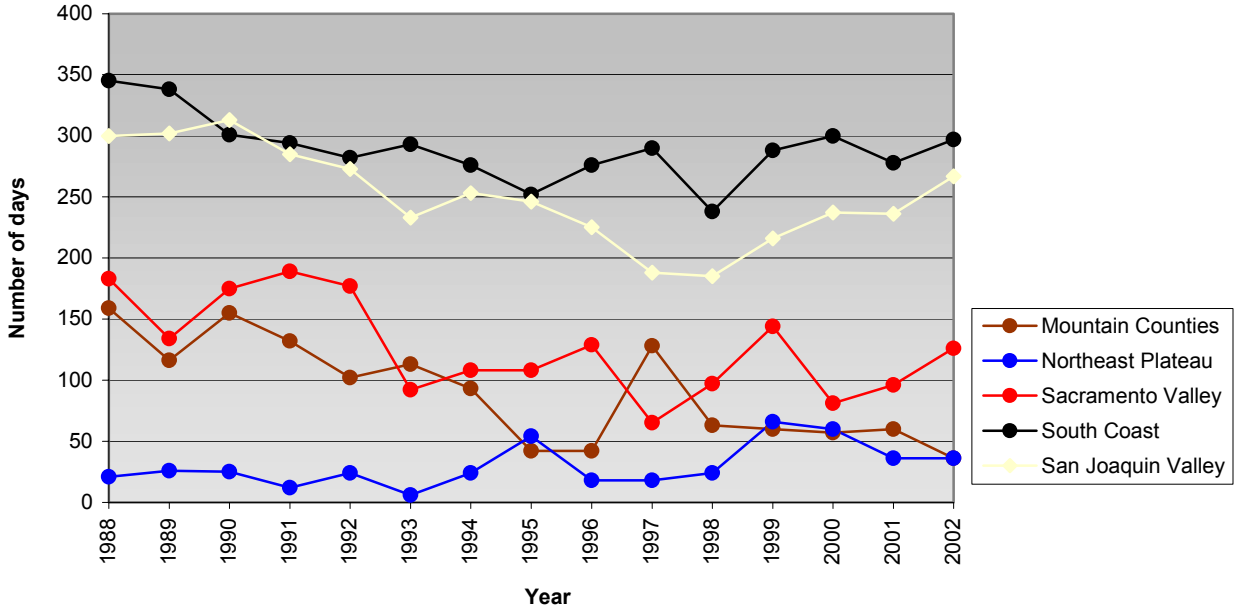
PM10 non-attainment levels have improved in the South Coast Air Basin over the last ten years. However, the South Coast air basin had 297 days of non-attainment in 2002. The primary cause of the non-attainment days was dust from paved and unpaved roads. As with the South Coast air basin, PM10

levels within the San Joaquin Valley air basin have improved slightly over the last ten years. With 267 non-attainment days, the San Joaquin Valley air basin has a high level of non-attainment. Sources include dust from vehicle travel on unpaved and paved roads, agriculture, waste burning, and residential fuel combustion (Figure 3).

Other air basins with overall lower levels of PM10 are also of some concern. While PM10 levels have improved within the Sacramento Valley air basin over the longer term, there were still 126 days of non-attainment in 2002. Another air basin of concern is the Northeast Plateau where there has been a slight increase of PM10 levels over the last ten years. With 36 days of non-attainment in 2002, the Northeast Plateau air basin raises questions over its trend and causes in air quality (Figure 3). While dusts from construction and fuel combustion are the likely causes of PM10 in the Sacramento Valley air basin, sources in the Northeast Plateau air basin are undetermined.

Figure 3 shows the number of days per year PM10 levels exceeded the State standard from 1988 through 2002.

Figure 3. Number of days PM10 exceeded state standard for selected air basins, 1998-2002



Source: California Air Resources Board (ARB), 1999

Attainment designations for State air quality regulations in forest and rangeland air basins

The California Health and Safety Code section 39607(e) requires the ARB to establish and periodically review area designation criteria. These designation criteria provide the basis for ARB to designate areas of the State as "Attainment," "Non-Attainment," or "Unclassified" for the State standards. Both California and the federal government use monitoring data to designate areas according to their attainment status for most of the pollutants with ambient air quality standards. A non-attainment designation indicates that the air quality violates an air quality standard.

To identify the severity of the problem and the extent of planning required to improve the situation, non-attainment areas are assigned a classification that is commensurate with the severity of the air quality problem (e.g., severe, serious, moderate) as shown below:

- **unclassified:** a pollutant is designated unclassified if the data are incomplete and do not support a designation of attainment or non-attainment;
- **attainment:** a pollutant is designated attainment if the State standard for that pollutant was not violated at any site in the area during a three-year period;
- **non-attainment:** a pollutant is designated non-attainment if there was at least one violation of a State standard for that pollutant in the area; and
- **non-attainment/transitional:** is a subcategory of the non-attainment designation. An area is designated non-attainment/transitional to signify that the area is close to attaining the standard for that pollutant.

Key attainment results for 1997, 1998, and 1999 were summarized by Garcia (2000) as follows:

- Several counties within the Mountain Counties and San Joaquin Valley air basins were in non-attainment for O_3. Most other counties in the Mountain Counties and San Joaquin air basins were not classified.
- For PM10, all air basins were classified as non-attainment in 1997 and 1998, except for several unclassified counties.
- With carbon monoxide (CO), most air basins are in attainment status, primarily due to the reductions in vehicle exhaust emissions.
- Currently, all air basins in California are unclassified for attainment of visibility (except Lake County is classified as attainment).